Acoustic Voice Quality Index (AVQI) in Carnatic singers

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CERTIFICATE

This is to certify that this dissertation entitled **"Acoustic Voice Quality Index (AVQI) in Carnatic singers"** is a bonafide work submitted in part fulfillment for the degree of masters of Science (Speech language pathology) by the student holding Registration number: 18SLP019. This has been carried out under the guidance of a faculty member of this institute and has not been submitted earlier to any other university for the award of any other Diploma or Degree.

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CERTIFICATE

This is to certify that this dissertation entitled **"Acoustic Voice Quality Index (AVQI) in Carnatic singers"** has been prepared under my supervision and guidance. It is also certified that this has not been submitted earlier to any other University for the award of any other Diploma or Degree.

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DECLARATION

This is to certify that this Master's dissertation entitled **"Acoustic Voice Quality Index (AVQI) in Carnatic singers"** is the result of my own study under the guidance of Dr.T. Jayakumar, Associate Professor in Speech Science, Department of Speech Language Science, All India Institute of Speech and Hearing, Mysore, and has not been submitted earlier in other University for the award of any Diploma or Degree.

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UNNIKANNAN

AMMA & ACHAN

ACKNOWLEDGMENTS

"JAI SRI RAM JAI HANUMAN"

Life is about laughing and living in good and bad times, getting through whatever comes our way and looking back with a smile. Dear **God** thank you for being there, blessing me, protecting me and supporting me through all tough and hard times.

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Chapter-I

Introduction

Voice, the sound produced by the vibration of vocal folds and influenced by vocal tract transfer function. It is the vehicle of speech and one of the primary aid through which most of us project our professionalism and influence are listeners (Prasad, 2012). *"*Voice performs the musical accompaniment to make speech in tuneful, pleasing, audible and coherence, being essential to efficient communication by the spoken word" (Greene, 1964).

Stemple (1993) describes professional voice users as those people who are directly dependent for their livelihood on "vocal communication". It is increasingly being realized that a substantial section of our population vocalizes for a longer period of time to earn their livelihood", (Titze & Sundberg, 1992). It includes singers, actors, teachers, radio and TV announcers etc. Even though they all come under the umbrella term professional voice users the range of quality and vocal requirements may vary among them.

Koufman (1998) classified professional voice users into four levels based on the individual's professional voice requirement and vocal load. They are level I: Elite vocal performer (Actors &Singers), level II: Professional voice user (lectures,teachers. etc), level III: Non-vocal professional (lawyers, businessman), level IV: Non-vocal non-professional (office workers, factory workers etc).

Indian Classical singing is regarded as one among the old form of music in the globe from the ancient Indian vedic period itself. Indian classical singing has two branches they are Carnatic (South Indian) and Hindusthani (North Indian).

Carnatic singing is a vocal style with predominantly low-pitched music integrated in higher-pitched vocal nuances, loud and open throat (Arunachalam & Boominathan, 2014) .Carnatic singing consists of saptawarams meaning seven primary notes or swarams, they are (sa, ri, ga, ma, pa, da, ni) with 22 intervals (tones, shruthi) .Raagam and taalam are the basic requirements of this singing , raagam referring to the musical scale and taalam to the rhythm of the singer. There are a few list of prerequisites for a good singing which was given by an eminent personality, Sarangadeva they are, rakthi (attractiveness), gambhiryam (loud), mardavaih (beautiful), ganata (rich), taara (pleasantness in the higher octaves), anudhvani (richness in the harmonics), madhuryam (sweetness), and kanthih (smooth and bright) (Durga, 1997).

The analysis of voice includes subjective and objective evaluation; the subjective evaluation is done by the speech pathologist which can be further supported by the instrumental analysis and the self-perceptual analysis by the client. The perceptual analysis is solely based on the voice pathologist perception of a particular voice sample with his or her mental reference to the normal voice characteristics. This is performed by listening to the speech and reading samples of the individuals and is rated on standardized perceptual rating scales. For instance, GRBAS (Hirano, 1981) and CAPE-V (Kempster et al., 2009) most frequently used perceptual rating scales for voice assessment. Voice is assessed objectively through acoustic, aerodynamic and imaging techniques. Furthermore, using self-rated measures such as voice handicapped index which evaluates

the effect of vocal problems on daily operations and the quality of life of the people (Jacobson et al. 1997).

Acoustic analysis of voice includes various spectral and cepstral parameters which can be used for both diagnoses as well as tracking intervention efficacy in voice disorders. These are frequently used by the Speech-language pathologist since the method is non invasive, timely and simple to interpret. It has been used for diagnostic investigations as well as to track the treatment efficacy (Carding et al., 2009). It involves procedures such as inverse filtering autocorrelation spectrum, cepstrum to extract the frequency related measures, amplitude related measures, perturbation related measures, noise harmonic related measures, and measure of voice continuity (Dejonckere & Lebacq, 1996; Hirano et al 1988; Picirillo et al., 1998 and Wolfe et al., 1995). Despite of many objective voice parameters, most of the acoustic parameters found to have poor correlation with perceptual analysis and limited test-retest reliability (Bauser & Drinnan, 2011; Hall & Landanl, 1995; HeuerSataloff et al.,1996). Awan and Roy (2006) stated that most acoustic parameters are limited in validity when used for diagnosis or documentation purpose (single parametric measure). In addition, several researchers proposed, multi parametric measurements which has multiple objective parameters in evaluation of voice quality could be superior than single parametric measurements (Klein et al., 2000; Michaclis et al., 1998 ; Ravis et al., 2001 ; Vaissiere et al , 2003)

Dysphonia Severity Index (Wuyts et al. 2000), Acoustic Voice Quality Index (Maryn et al., 2010), Cepstral Spectral Index of Dysphonia (ADSV model 5109, Kay

PENTAX Montvale,NJ) are few of the multi parametric procedures to measure the quality of voice as reported.

Dysphonia Severity Index (DSI) is a regression equation obtained from a combination of four single parameters namely highest frequency (H2), lowest intensity (dB), maximum phonation time (seconds) and jitter (percent). Studies indicated that DSI was a good correlate of the perceptual dysphonia severity. For instance, Hakkesteegt et al., (2006) reported a good correlation of DSI with the grade of the GRBAS scale. They reported lower DSI scores in dysphonics compared to that of normals. Neelanjana and Jayakumar (2011) reported a significant correlation between CAPE-V and the DSI. The DSI values ranges from +5 to -5 wherein, +5 indicates normal voice and -5 indicates servere dysphonia, hence it is been used as a tool to differentiate normal versus abnormal voice (Wuytsetal.,2000). Further, several studies had reported the successful use of DSI in documenting the outcomes of surgical as well as therapeutic management of voice disorders (Hakkesteegt et al.,2006).

Awan et al., (2012) reported the intra-subject variability on the DSI and found that two parameters of DSI (the lowest intensity and the jitter percentage) showed higher variability among its four constituent parameters Similarly, Jayakumar and Savithri in 2012 reported the significant geographical and ethnic impact on DSI, particularly on its constituent parameters, highest F0 and maximum phonation time.

Factors such as instrumentation, age and gender were reported to influence the DSI value. Measuring DSI requires sophisticated instruments for precise measurements of constituent parameters, particularly the lowest intensity. Further, the DSI estimates

dysphonia severity using only the sustained vowel task which does not give information about speaker's habitual speaking voice.

Cepstral spectral index of dysphonia (CSID) is another multi parametric measure that utilizes both the sustained vowels and continuous speech. CSID is accessible with Analysis of Dysphonia in Speech and Voice program (ADSV model 5109, Kay PENTAX., Montvale, NJ). It includes cepstral parameters and spectral such as cepstral peak prominence (CPP), the low to high spectral energy ratio (LH spectral ratio and its standard deviation are acquired independently from both the continuous vowel and the connected speech task. It also provides an estimation of the extent of dysphonia for each assignment automatically. CSID values range 0 to 100 but sometimes it generates below and above that which indicates extremely periodic voice and profoundly aperiodic voice respectively. Although CSID is a promising tool for evaluation of voice dysphonia, it is not been used as widely as compared to AVQI. The dynamic range of CSID is greater. Hence, there can be a possibility of poor intra reliability.

Another multi parametric measure, Acoustic Voice Quality Index (AVQI) comprises six constituent parameters, they are Cepstral peak prominence (CPPS), Harmonics to noise ratio (HNR), shimmer local, Shimmer dB (ShdB), the slope of long term average spectrum (slope) and tilt of the trend line through the long-term average spectrum (tilt). It incorporates both spectral and cepstral parameters and continuous speech task in praat software using AVQI script. It utilizes a script of 0 to 10 to quantify the quality of voice where 0 shows normal quality of voice and 10 suggest severe dysphonia.

AVQI is designed as AVQI = 2.571*(3.295-0.111*CPPS-0.073*HNR-0.213*SL+2.789*ShdB-0.032*Slope+0.077* Tilt) Maryn et al.,(2010). Maryn and Weenink (2015) derived a better version of AVQI version 2 which is AVQI= 9.072-0.245*CPPS-0.161*HNR-0.470*SL+6.158 * ShdB-0.071*Slope+0.170*Tilt

AVQI is discovered to be consistent across distinct languages related to distinct geographical areas. In Indian language, Malayalam and Kannada has a value of 3.03 (Jose,2017), AVQI value for Kannada speaking children between 10 – 12 years was 3.74 (Seshashri, 2018), Tamil has a value of 2.76(Vishali,2019) English has a value of 3.25 (Maryn,2014), German has a value of 2.70 (Barsties& Maryn,2012), French has a value of 3.07 (Maryn et al., 2014), Dutch has a value of 2.80 (Barsties & Maryn, 2015) Lithuanian has a value of 2.97(Uloza etal.,2017), Japanese has a value of 3.12 (Hosokawa et al., 2017). Marynet al., (2014) measured AVQI in different language speaking individuals including English, Dutch, French and German and confirmed good cross lingustic validity and diagnostic accuracy.

Barstices and Maryn (2013) reported good test- retest reliability in AVQI. Also, Benoy (2017) revealed good AVQI testretest reliability and a strong correlation with severity of perceptual dysphonia. They also revealed that AVQI distinguished mild and moderate severity dysphonia. Reynolds et al., (2012) assessed pediatric voice disorders in 67 participants using AVQI and compared objective result with GRBAS scale. Moderate level of correlation was found between AVQI and GRBAS.

Núñez-Batalla et al., (2017) analyzed sustained vowel of 60 normal and 58 voice disorders using AVQI and compared it with overall perceived voice quality A significant

correlation was found between them and thus the study demonstrated AVQI as clinically feasible to measure dysphonia severity. Barsties et al. (2017) researched gender and age impact among normal adults on AVQI and DSI between the age range of 20-79, including 68 females and 55 males and found no particular gender effect in both measures and also DSI had greater correlation with age while AVQI did not have correlation with age.

Uloza et al.,(2018) explored and compared the diagnostic precision of AVQI and DSI, results revealed that higher level of diagnostic accuracy for AVQI with more correlation to the auditory perceptual measurement of voice in comparison to the DSI. Therefore, the AVQI has a more reliable voice screening potential compared to DSI.

AVQI was measured in 26 Dutch theatre artists by Dhaeseleer et al., (2016) and they analyzed their sustained phonation and continuous speech prior and after performance in praat software and found their mean AVQI value to be 3.48 which corresponded to mild dysphonia. They concluded that this high AVQI value can be attributed to violent vocal behavior and poor vocal hygiene.

Ravibabu and Maruthy (2013) contrasted the DSI of trained carnatic singers and n onsingers and discovered higher DSI scores on trained singers. Maruthy and Ravibabu (2015) contrasted the DSI between young and old Carnatic performers and non singers and found younger singers had higher DSI values and older singers had reduced DSI values. Prasad and Geetha (2015) compared the DSI scores of pre pubertal female Carnatic singers and nonsingers and found that for Carnatic singers the DSI value was greater.

Balasubramanium et al., (2015) compared cepstral measure of Indian Classical Carnatic singers and non singers and found that singers have comparatively greater CPP and CPPS values. From the above mentioned researches it is being evident that singers have a predominant voice over non singers. Therefore we need to measure AVQI particularly in Carnatic singers under professional voice users. Hence the present study is focused to analyze the voice of trained Indian Carnatic singers Using Acoustic Voice Quality Index (AVQI)

Need of the study

From the previous studies AVQI has been proved as one of the reliable measurements among the multi parametric measures that are attained using a software, which is easy for evaluation and interpretation .Several researches has been conducted to validate AVQI and hence several standard AVQI norms has been developed in different languages, age groups and also among professional voice users like theatre artist. According to Maruthy and Ravibabu (2013) there was a significant difference exists among trained younger Carnatic singers and non singers in terms of mean DSI values and some of its constituent's Highest fundamental frequency (F0-high) and Maximum phonation time (MPT). Hence, there is a possibility of existence of such a difference even for AVQI. Also, AVQI needs to be validated across professional voice user population.

Aim of the study

The aim of the study is to estimate AVQI data for Carnatic singers.

Objectives of the study

- To obtain the AVQI scores for Carnatic singers.
- To compare the AVQI score of Carnatic singers with non singers.

Chapter-II

Review of literature

The human voice is the product of the respiratory, phonatory, and resonatory systems. This multidimensional nature of voice involves assessment using different fields, such as visual imaging, acoustic, perceptual, self-rating, and aerodynamic. The acoustic voice analysis provides an objective and quantitative voice assessment and has found application for both clinical and research areas (Yu, Ouaknine, Revis, & Giovanni, 2001).

According to Vennard (1962) singing is defined as producing musical tone by means of voice and it requires variety of phonatory, articulatory and resonatory adjustments and differs from speaking in terms of both qualitatively and quantitatively specially on parameters like rhythm and melody (Luchsinger, 1965). Singers are often mentioned as "vocal athletes," because they put on their voice unique and heavy demands are placed on their voices. Singers have a higher phonatory agility, stamina, and strength which helps them to satisfy their vocal demands while performing complex laryngeal maneuvers during singing (Zeitels et al., 2002). Such talents are often developed through experience and singing practice, thus making a difference in physiological, acoustic, and perceptual measures between the voices of singer and non singer.

Singing Power Ratio

Lundy et al. (2000) analyzed Singing Power Ratio and acoustic parameters in singing students between their singing and speech using MDVP. Shimmer and NHR were

higher in spoken tones. There was no significant difference in SPR and jitter between singing and speaking voice in SPR.

Mendes et al. (2003) studied the effectiveness of voice training in 14 voice majors. Tasks were singing 'America the Beautiful' and MPFR which contained frequencies lower in modal register to highest in falsetto register. Fo improved significantly in 3rd and 4th semester compared to 1st semester. As the number of semesters increased SPL of 90% level of MPFR increased significantly. There was no significant difference for vibrato due to vocal training. For the vowel /i/,/a/ singer formants were identified. There was no difference in singer formants as a result of vocal training.

Dysphonia Severity Index

Bernadette et al. (2005) assessed the success of the voice training system with 23 qualified voice users receiving 1 year vocal hygiene training and 2 years voice training. European Laryngological Society protocol which contains DSI and VHI was used for evaluating the voice. Voices were analyzed during 9th and 18th week of voice training. DSI score was found to be improved better on 9th week of training than 18th week. In VHI good improvement was seen in 18th week than 9th week.

Awan and Ensslen in 2010 compared the voice of trained and untrained vocalist using DSI. For the study 30 experienced singers and 36 untrained participants between the ages of 18 and 30 years were included. The result finding suggested that trained singers have higher DSI value (6.48) than untrained singers (4.00). The significant difference was seen groups for three of the components such as F0 high, Intensity low and jitter of the DSI.

Maruthy and Ravibabu in 2015, aimed to compare DSI parameters between Classical Carnatic singers and non-singers and the authors also tried to verity if there was an age effect in both the groups. The study included 30 female Carnatic singers who were divided into two groups of 15 older singers and 15 younger singers. They were compared to 30 non-singers who were age and gender matched the parameters essential for calculation of Dysphonia severity index (DSI) were measured. The results denoted that the singer group to be having greater highest phonational frequency, longer phonation duration and higher DSI measures. It was also observed that, the younger participants had higher MPD, highest phonational frequency and DSI scores when compared to the older participants. Prasad and Geetha in 2015 aimed at comparing the DSI scores of pre pubertal female carnatic singers and non singers and found that for carnatic singers the DSI value was greater.

South Indian Carnatic classical Music

Carnatic singing, the classical music of South India, is a highly developed form of art, learned through intensive practice from masters (usually called gurus). It needs a strong voice with emphasis on loud and low-pitched singing. It is essential for Carnatic singing to excute long musical phrases or notes across different octaves, tempos, and with distinctly clear articulation of vowels and consonants. Carnatic singing emphasizes the singing with correct breathing on a right shruthi or tonic pitch. In Carnatic singers, together with tonal quality, open-throated singing with forward placement of voice idealizes a strong and superior voice. Scientific literature explains different aspects of classical North Indian and South Indian vocal development and ornamentation. The vocal

lessons in Carnatic singing are rated with pitch matching skills on, voice over range versatility and expected open-throated voice with good tone placement.

A research by Balasubramanium et al., 2015used cepstral measures to evaluate singer's voice. Thirty Indian female classical Carnatic singers and thirty non singers were involved in this study. Phonation of vowel /a/ was recorded at their habitual pitch and loudness and the cepstral peak prominence (CPP) and smoothened cepstral peak prominence (CPPs) were analyzed using the Hillenbrand algorithm and the results revealed an increased mean raw score in classical Carnatic singers than non singers. Hence the study indicated increase cepstral parameters among the singers in comparison with non singers; this can be traced in singers voice to the harmonic organization.

A study done by Umesh in 2015 aimed at investigating the cepstral measures such as cepstral peak prominence(CPP) and smoothened cepstral peak prominence (CPPs) along with fundamental frequency in three different grades (junior,senior and vidwath) of carnatic classical singers. The participants enrolled for the study were 60 carnatic classical singers of both genders and three grades 10 male and female in each group .They analyzed the phonation sample of vowel /a/. Cepstral coefficients and fundamental frequency was measured using the software (version 1.65) Speech tool and the results revealed there was no significant differences in cepstral measures(CPP and CPPs) across three grades this can be attributed to the attainment of a good harmonic structure in the initial stages of training itself. However, among female singers vidwath grade singers have higher cepstral measures which reflect a good harmonic organization of voice in comparison with the junior and senior grade singers.

Acoustic voice quality index

The AVQI is a six-variable acoustic model which quantifies the overall voice quality using both sustained vowel and continuous speech. comprises six constituent parameters, they are cepstral peak prominence (CPPS),harmonics-to-noise ratio(HNR), shimmer local, shimmer dB(ShdB), the slope of long-term average spectrum (slope) and tilt of the trend line through the long-term average spectrum (tilt) It incorporates both spectral and cepstral parameters and measured using sustained vowel and continuous speech task in praat software using AVQI script. It utilizes a scale of 0 to 10 to quantify the quality of the voice where in 0 shows normal voice quality and 10 suggests severe dysphonia.

AVQI is designed as AVQI=2.571*(3.295-0.111*CPPS-0.073*HNR 0.213*SL+2.789*ShdB0.032*Slope+0.077* Tilt) (Maryn et al., (2010). Maryn and Weenink (2015) derived a better version of AVQI which is AVQI= 9.072-0.245*CPPS-0.161*HNR0.470*SL+6.158*ShdB-0.071*Slope+0.170*Tilt. A study conducted by Maryn et al., in 2010 with Dutch speakers revealed that a score of 2.95 or below obtained on AVQI suggested to be normophonemic and also stated that higher the AVQI scores more the quality of voice affected. In a study by Reynolds et al., (2012) found a high diagnostic accuracy on AVQI suggesting the application of this in paediatric voice. They also mentioned, AVQI correlates with GRBAS scale and that AVQI is an appropriate tool for assessment and diagnosis of voice disorders in children.

Kankareetal. (2015) made a voice quality assessment of the Finnish speaking population using AVQI. A total of 50 Finnish native speakers were accepted as participants, with 22 voice patients and 28 healthy individuals .Phonation and reading task were given .Five experts evaluated the severity of dysphonia using GRBAS scale.

Authors found that an excellent diagnostic accuracy was AVQI which indicated ROC as 0.898. The mean AVQI dysphonic voice scores for a safe voice were 3.95(SD1.88) and 1.48 (SD 0.67). The Likelihood ratio (LR) confirmed a good result,with the diagnostic accuracy of AVQI threshold being 2.23. Accordingly, Authors concluded that AVQI is a reliable voice evaluation method for Finnish speaking individuals.

AVQI was measured in 26 Dutch theatre artists by Dhaeseleer et al., (2016) and they analyzed their sustained phonation and continuous speech prior and after performance in praat software and found their mean AVQI value to be 3.48 which corresponded to mild dysphonia. Fifty percent of the theatre actors testified as having (occasionally or often) vocal complaints subsequent to performances. They also identified occurrence of vocally violent behavior and pitiable vocal hygiene practices. They concluded that this high AVQI value can be attributed to violent vocal behavior and poor vocal hygiene.

Núñez-Batalla et al., (2017) measured the overall extent of dysphonia through meta-analysis. This study enrolled 108 participants. In that 58 people were dysphonic and 60 volunteers in the age range of 20-60 years. These people were asked for phonation and also made to read a Spanish passage for auditory perceptual voice evaluation. For auditory-perceptual study two experts used the GRABS and CAPE-V. The result showed a significant difference between the two groups, and also made a distinction between the healthy volunteers and the dysphonic individuals.

The measured AVQI was noted to be an average of about 7.3 with a standard deviation of 1.07, ranging from 5.3 to 9.8, for the sustained vowels. An average of about

9.7 was found to be the AVQI obtained for phrases, with a standard deviation of 0.70 and a range of 8.5 to 11.6. Hence the findings from the study found a strong correlation between the overall perception of voice quality and the AVQI score, and a significant difference exists between the normal and dysphonic voices on AVQI, thus concluding that this research demonstrates the therapeutic utility of the AVQI as a measure of extent of dysphonia .

A similar study was done by Uloza et al (2017) the aim was to validate and investigate the feasibility and robustness along with diagnostic accuracy of acoustic voice quality indexin Lithuanian language (LT) for that 46 participants with normal voices and 138 participants with different voice disorders, who are native Lithuanian speakers, were taken for the study. Reading and phonation task was given .Using GRBAS and CAPE-V auditory perceptual analysis was carried out. All voice samples were acoustically analyzed to obtain an AVQI-Lithuanian score,. It was confirmed that both the auditory-perceptual judgment and AVQI-Lithuanian scores significantly correlated.

The study done by Hosakawa et al. (2017) aim to measure the concurrent validity, responsiveness to change and diagnostic accuracy of the Japanese-speaking population Japanese voice assessment of AVQI. The study considered a total of 336 voice recordings, and an auditory-perceptual assessment was used to determine the overall voice quality. The validity and sensitivity of AVQI for change and diagnostic accuracy were calculated. Receiver operating characteristics (ROC) analysis showed excellent diagnostic accuracy for dysphonic-and normophonic voice discrimination. The best 3.15 AVQI threshold level corresponded to a 72.5 percent sensitivity and 95.2 percent specificity, respectively with the positive and negative probability ratios of 15.1 and0.29.

Thus, the authors concluded that AVQI is used as a measure for overall assessment of voice quality and voice therapy outcomes in the Japanese-speaking individulas.

Uloza (2017) examined the gender and age impact on AVQI and DSI. A total of 123 vocally healthy people were assessed in this study. A sustained portion of vowel /a/ and a reading passage was taken for the acoustical analysis. Authors suggested that AVQI values are not gender and age dependent in which DSI values are not gender dependent but marginally linked to age.

The study done by Benoy in 2017 aimed at establishing reference measures for AVQI and to validate AVQI with the perceptual measure (GRBAS scale) for individuals with normal voice quality and individuals with dysphonia within the Indian context. They considered Malayalam and Kannada speakers within the age range of 20 to 50 years. A total of 120 individuals participated in the study. Sustained phonation of /a:/ as well as reading sample were obtained and the corresponding AVQI measures were obtained. The samples were also subjected to perceptual analysis using GRBAS. The results revealed that, there was a very good test-retest reliability of AVQI and its individual parameters. The normative value of AVQI for the Indian Malayalam and Kannada speaking population is 3.03 (±0.32). This value is in accordance with the AVQI values for several other languages reported worldwide. Effect of gender, language as well age group was not significantly present for the AVQI scores in their study.

Kim et al in 2018 checked the viability of the AVQI cut-off values and accuracy of diagnosis in the Korean population in discriminating between normal and dysphonic voices. A total of 1,524 native Korean subjects were pursued for phonation of vowel/a/

and reading text was given further an auditory perceptual evaluation using GRBAS (Grade) and CAPE-V (overall severity) was administered. the cut-off values of AVQI, G, and OS (overall severity) for receiver characteristic curve analysis were <3.33, 0.00, <22.00. The findings suggested that AVQI has excellent diagnostic precision in distinguishing normal and dysphonic voices. Accordingly, the authors concluded that AVQI is a reliable method in Korean speaking population for evaluating overall voice quality and quantifying dysphonia.

The Acoustic Voice Quality Index was studied by Seshasri in 2018 in 80 typically developing children with Kannada language aged 10-12 years. The research contains phonation and reading task. The author found no impact on age and gender for AVQI. The mean AVQI was 3.35 for 10-11 years, with SDof 0.60.The mean AVQI scorefor11-12year males was 4.09 with SD of 1.03 and females,3.85 with SDof 0.65. Author also concluded that AVQI was significantly higher for older children, due to initiation of mutational changes inchildren of these age range.

Maryn et al, (2018) explored and compared the diagnostic precision of AVQI and DSI, results revealed that higher level of diagnostic accuracy for AVQI with more correlation to the auditory perceptual measurement of voice in comparison to the DSI Therefore, the AVQI has a more reliable voice screening potential compared to DSI.

Pebbili et al. (2019) assessed the diagnostic accuracy of AVQI. Voice samples of 71 individuals (18 females and 53 males) with voice disorders were analyzed using AVQI. Voices were perceptually evaluated by 3 experienced SLP's using GRBAS scale. Significant concurrent validity was found for AVQI. Score of AVQI was found to be

increased with increase in dysphonia severity. AVQI was found to have more accuracy in discriminating slight versus moderate dysphonia severity, moderate versus severe dysphonia severity while, lesser accuracy was found in discriminating normal versus mild dysphonic voice.

Faham et al., (2019) investigate can AVQI be a screening tool along with auditory and perceptual perception of voice. Voice samples of 128 teaching students were analyzed. The tasks were to phonate /a/ and read standardized passage. Significant but weak correlations were found between Gmean and AVQI and its two parameters, harmonic-to-noise ratio and smoothed cepstral peak prominence.

Jayakumar et al., (2020) studied the effect of age and gender on AVQI. The study included a total of 200 participants with 50 participants in pediatric group, 100 in adult group and 50 in older adult group. The findings from the study revealed that adults obtained a lower AVQI score compared to pediatric and older adult groups, which show a statistical significance. Hence forth there was a significant age effect demonstrated by AVQI and its constituents and the values of AVQI were found to be more stable in adults than in pediatric and older adult groups. AVQI values did not differ significantly across older adult and pediatric groups. Effect of gender was not seen in AVQI.

Hence from the Literature it is clear that AVQI is a promising tool in analyzing quality of voice. However, there is a need of validation of AVQI in professional voice users. So, the present study was focused in estimating AVQI value for Carnatic singers and compares the values with non-singers.

Chapter-III

Method

Participants

Thirty trained Carnatic classical singers, between the age range of 18-35 years, with no history of any vocal complaints with minimum 5 years of experience in singing was considered for the study. Age and gender matched control group was taken. All the participants were recruited from Kerala, India .Participants fulfilling the inclusion and exclusion criteria were selected for the study. Table 3.1 shows the details of the participants. Subgroups were made based on gender to find whether gender has an effect on AVQI values. The thirty Carnatic classical singers were divided in to two groups based on their experience with one group, who has experience of less than 15 years and the other with experience of 15 years and above. The number of Carnatic singers on each group were18 and 12 respectively. This was made to find out whether experience has an effect on AVQI.

Inclusionary criteria

- All the participants should be trained Carnatic classical singers with more than 5 years of experience
- Participants will be rated by a Speech language pathologist to ensure perceptually normal voice.

Exclusion criteria

- Singers with experience less than 5 years.

- Participants with vocal complaints report.
- Participants with the history of smoking, alcohol consumption
- Participants with the history of voice disorders or other laryngeal pathology.
- Participants with infections associated with vocal tract, or with any history of chronic obstructive pulmonary disorder, asthma or any other lung infections.
- Participants with any hearing, neurological impairment or communication disorder

Table 3.1

Details Of The Participants

Carnatic Singers		**Non singers**	
Male	Female	Male	Female
10	20	10	20

Stimuli

The present study included speech samples of sustained phonation of vowel /a/ and reading sample of standardized Malayalam passage (Savithri & Jayaram, 2005)(Appendix)).

Procedure

The participants were explained about the need of the study and procedures in detail and a written inform consent was taken .The participants were made to sit on a

chair with an erect position, the recording was done in a quiet room with the microphone placed 15cm away from the mouth. The audio recordings was done using Olympus LS 100 digital voice recorder with a sampling frequency of 44.1 KHz and 16 bit resolution in .wav format. All the participants were asked to produce sustained phonation of /a/ for minimum 8 seconds and to read the passage at comfortable pitch and loudness. For phonation and reading tasks the trials was three and two respectively. From the sustained vowel /a/ the middle steady portion of 3 seconds and third to sixth sentences of the reading passage from continuous speech task which is in .wav format was taken and renamed as 'sv' for sustained vowel and 'cs' for Continuous speech respectively. Among the given trails those with perceptually stable vowel phonation and fluent reading by the participants were taken for further analysis using AVQI script by Maryn et al., (2010).

Analysis

The recorded and renamed.wav files ('sv' and 'cv')was analyzed using Praat software (6.0.28 version) to obtain AVQI score. The algorithm developed by Maryn and Weenik (2015) was used measure AVQI. The script for AVQI algorithm for obtaining AVQI contains the following regression equation, AVQI= 9.072-0.245*CPPS-0.161*HNR-0.470*SL+6.158*ShdB-0.071*Slope+0.170*Tilt , this script was used for further analysis. The AVQI script given by Maryn et al., (2010) was copied on to a text file, and was named as 'AVQI script'. Following the selection of 'cs' and 'sv' files, the 'AVQI script' version 2.02 was 'run' in the Praat software (6.0.28 version). The screenshot of a step involved in this procedure is given under figure 3.1 .Figure 3.2 and 3.3 depicts the

final graphical AVQI output of Carnatic Classical Singers and non singers on Praat software.

Test-retest reliability was also administered, by which 10% of the sample was subjected to reanalysis using the same instrument and script. The reliability coefficient was 0.92.

Figure 3.1

Picture Revealing AVQI Script Version 2.02 Being Run On Praat Software ('cs'- continuous speech and 'sv'sustained vowel)

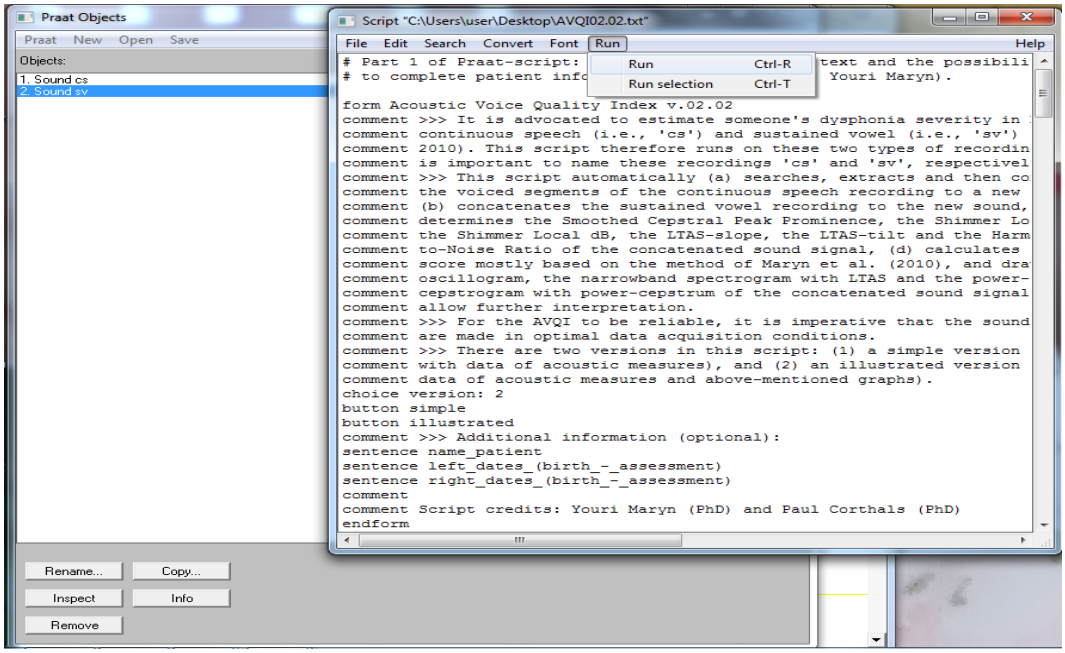


Figure3.2

Graphical Output Of Acoustic Voice Quality Index Results Of Carnatic Classical Singers.

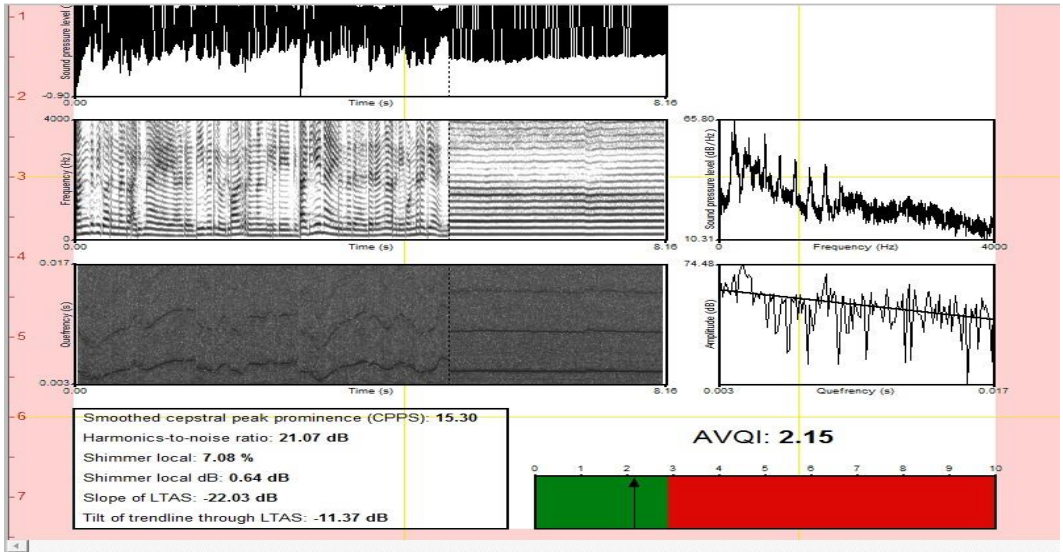
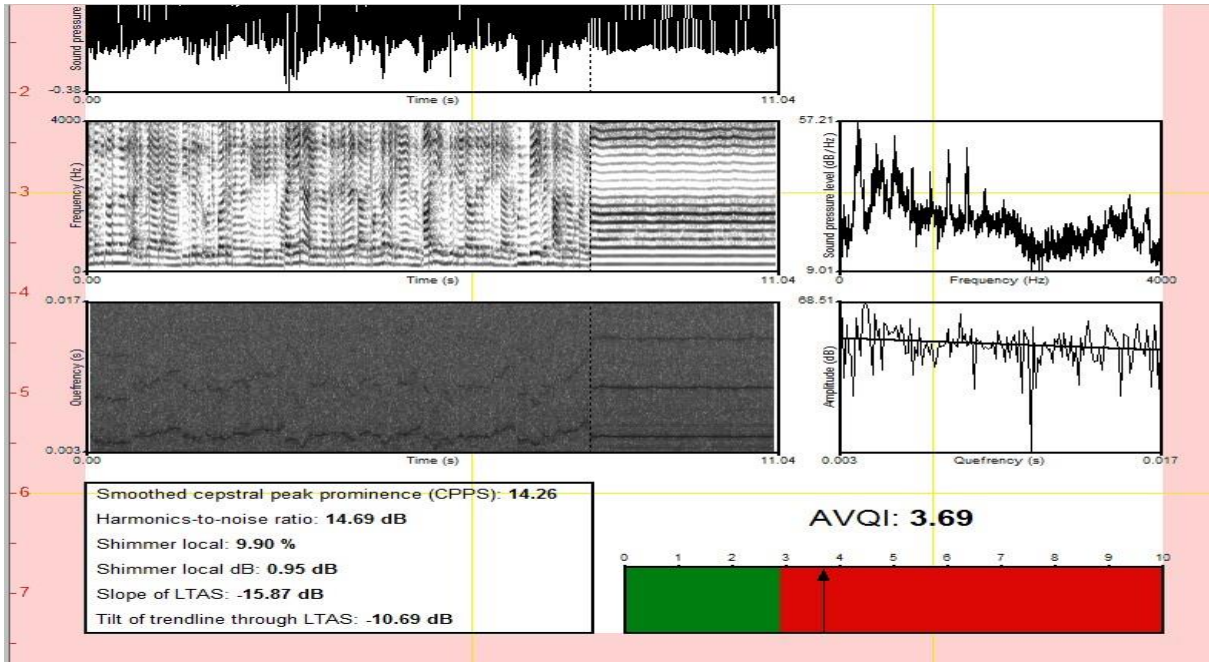


Figure 3.3

Graphical Output Of Acoustic Voice Quality Index Results Of Non Singers.



Statistical analysis

The obtained AVQI values for Carnatic classical singers and non singers was further taken to statistical analysis using Statistical Package for Social Sciences software (SPSS) version 20 to derive:

- ✓ The normality of the samples derived using Shapiro – wilk test for normality.
- ✓ The comparison between AVQI scores of Carnatic singers and Non singers.
- ✓ The effect of gender on AVQI and its constituent parameters.
- ✓ The effect of experience of singing on AVQI and its constituent parameters.

Chapter-IV

Results

The purpose of the present study was focused on obtaining AVQI scores in Carnatic singers and comparison of AVQI and its constituent parameters with non singers. Voice samples of 30 Carnatic singers and 30 Non-singers were collected for two vocal tasks such as phonation of vowel /a/ for minimum 8 seconds and reading sample using a standardized passage thereby their AVQI values were calculated. Descriptive and inferential statistics were carried out using SPSS software version 20. The results of this study will be discussed under the following Sub headings:

- Normality check for the data.
- Mean and standard deviation of AVQI and its constituent parameters.
- Effect of gender on AVQI and its constituent parameters.
- Effect of experience on AVQI and its constituent parameters.

Normality check for the data

In order to determine the normality of the samples selected for the study Shapiro Wilk's test was carried out with respect to the independent variables such as gender and population (Carnatic singer & Non singer). It was revealed that all the constituent parameters followed normal distribution with $p>0.05$ except for AVQI in Carnatic singers ($p=0.038$) and AVQI for females ($p= 0.019$) pertaining to variables such as population and gender respectively.

Comparison of AVQI and its constituent parameters between Carnatic singers and Non-singers

AVQI and its constituent parameters were obtained from a total of 30 Carnatic singers and 30 non singers. Descriptive statistics was implied for finding the mean and standard deviation for AVQI and its constituent parameters in singers and non singers. The Table 4.1 depicts the mean and standard deviation of AVQI and its constituent parameters for Carnatic singers and non singers. It was found that the mean value for AVQI was 3.64 (±0.65) for Carnatic singers however, non-singers obtained a higher value 3.99(±0.41).The values for CPPS in Carnatic singers was higher 13.96(±0.91) compared to non singers 13.39 (±0.99). Carnatic singers attained a higher mean value for HNR 17.24(±2.02) compared to non singers 16.13(±1.45). Results of Multivariate Analysis of Variance (MANOVA) suggest a statistical significance across the mean scores of Carnatic singers and non singers for AVQI (P=0.05) and HNR (P=0.01). Even though CPPS value were higher in Carnatic singers it did not show a statistical significance (p=0.06). All other constituent parameters such as Shimmer local, Shimmer Db, Tilt of LTAS and slope of LTAS was found not to be significant. Figure 4.1 depicts graph of comparison of AVQI and its constituents across Carnatic singers and non singers.

Table 4.1

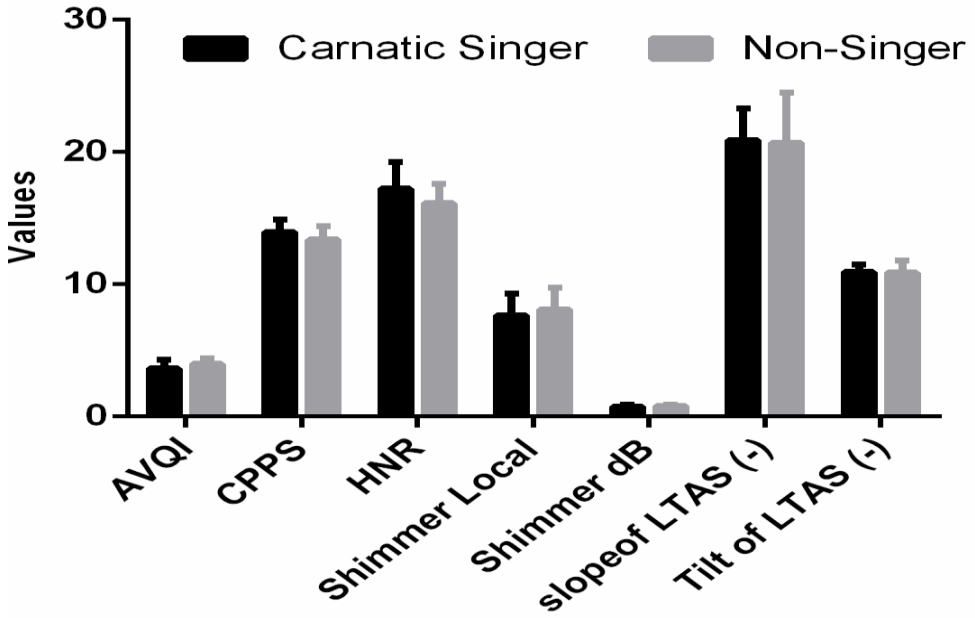
Mean Standard Deviation F Value And P Value of AVQI and It's Constituent Parameters Between Carnatic Singers and Non Singers

Parameter	**Carnatic Singers. Mean and SD**	**Non-singers Mean**	***F*-value**	***p*-value**
AVQI	3.64(±0.65)	3.99(±0.41)	3.85	0.05*
CPPS	13.96(±0.91)	13.39(±0.99)	3.65	0.06
HNR	17.24(±2.02)	16.13(±1.45)	6.28	0.01*
Shimmer local	7.67(±1.61)	8.12(±1.61)	0.13	0.71
Shimmer dB	0.77(±0.11)	0.81(±0.09)	0.64	0.42
Slope of LTAS	-20.92(±2.3)	-20.71(±3.7)	0.11	0.73
Tilt LTAS	-10.92(±0.5)	-10.88(±0.9)	0.002	0.96

*p≤0.05

Figure 4.1

Comparison Of AVQI And Its Constituent Parameters In Carnatic Singers And Non Singers.



Effect of gender on AVQI scores and its constituent's scores

The effect of Gender on AVQI and its constituents were analyzed under three subsections. Subsection I considered the effect of gender on AVQI and its parameters across singers and non singers, Subsection II considered the effect of gender on AVQI and its parameters within the group of Carnatic classical singers and Subsection III considered the effect of gender on AVQI and its parameters within the group of Non singers.

While analyzing subsection I it is clear from the table 4.2 that females obtained a comparatively lower mean value of AVQI 3.66(±0.59) than males 4.10(±0.39). The same trend was seen for some of the constituent parameters such as shimmer local and shimmer dB were female shows a lower mean value and the values obtained are 7.54(±1.51) and 0.77(±0.11) respectively. The obtained values for males were, Shimmer local 8.55(±1.64) and shimmer db 0.82(±0.09). However, mean value for HNR was higher in females compared to males.

Multivariate Analysis of Variance (MANOVA) was carried out to find the effect gender on AVQI and its constituent parameters obtained after comparing between total male and female participants of the study. The values are depicted in table 4.2.
A significant difference was found across gender for AVQI scores (P=0.002) and constituent parameters such as HNR (P=0.00) and Shimmer local (p=0.01).

Table 4.3 and 4.4 depicts the mean and standard deviation of AVQI and its constituent parameters across gender for Carnatic singers and non singers respectively.

As observed from the table 4.3 it was seen that male Carnatic singers obtained a higher mean value for AVQI, shimmer local and shimmer db than female Carnatic singers. Also, male Carnatic singers had a lower HNR value than females. While analyzing gender effect on non singers there was no statistical significance observed except for HNR were male non singers obtained a lower value than females. Further, MANOVA was carried out to find the effect gender on AVQI and its constituent parameters in Carnatic singers and Non singers separately. A significant difference was found between gender in Carnatic singers for AVQI (P=0.004) and its constituent parameters such as HNR (P=0.000), Shimmer local(p=0.001) and Shimmer dB(p=0.002).However, for Non singers there was no significant difference seen except for HNR (p=0.002). Figure 4.2 depicts the comparison of AVQI and its constituents of male Carnatic singer and male non singer and figure 4.3 depicts the comparison of AVQI and its constituents of female Carnatic singer and female non singer.

Table 4.2

Mean, Standard Deviation F Value And P-Value Of AVQI And Its Constituents Across Gender

Parameter	**Male Mean and SD (n=20)**	**Female Mean and SD (n=40)**	***F*-value**	***p*-value**
AVQI	4.10(±0.39)	3.66(±0.59)	10.96	0.002**
CPPS	13.50(±0.82)	13.77(±1.06)	01.29	0.260
HNR	15.16(±1.15)	17.51(±1.59)	45.13	0.000**
Shimmer local	8.550(±1.64)	07.54(±1.51)	06.70	0.012*

Shimmer dB	0.821(±0.09)	00.77(±0.11)	03.40	0.067
Slope of LTAS	-21.45(±3.42)	-20.47(±2.9)	01.60	0.400
Tilt LTAS	-10.74(±0.78)	-10.91(±0.76)	0.710	0.204

*p<0.05 **p<0.003

Table 4.3

Mean, Standard Deviation, F Value And P-Value Between Gender Within The Group Of Carnatic Singers

Parameter	**Male Mean(n=10)**	**Female Mean(n=20)**	***F*-value**	***p*-value**
AVQI	4.10(±0.41)	3.42(±0.63)	9.6	0.004**
CPPS	13.61(±0.63)	14.13(±0.99)	2.2	0.144
HNR	15.21(±1.07)	18.26(±1.56)	30.72	0.000**
Shimmer local	08.98(±1.64)	7.02(±1.16)	14.33	0.001**
Shimmer dB	00.85(±0.09)	0.72(±0.09)	12.04	0.002**
Slope of LTAS	-21.8(±2.08)	-20.41(±2.41)	02.31	0.139
Tilt LTAS	-10.6(±0.56)	-11.00(±0.58)	02.39	0.133

**p<0.005

Table 4.4

Mean, Standard Deviation, F Value And P-Value Between Gender, Within The Group Of Non Singer

Parameter	**Male Mean and SD (n=10)**	**Female Mean and SD (n=20)**	***F*-value**	***p*-value**
VQI	4.14(±0.38)	3.92(±0.42)	1.86	0.183
CPPS	13.34(±1.02)	13.41(±1.00)	0.03	0.849
HNR	14.94(±1.20)	16.72(±1.18)	14.7	0.001**
Shimmer local	8.23(±1.69)	08.06(±1.62)	0.06	0.800
Shimmer dB	0.79(±0.08)	0.82(±0.10)	0.58	0.451
Slope of LTAS	-21.2(±4.64)	-20.4(±3.33)	0.33	0.568
Tilt LTAS	-10.8(±1.01)	-10.8(±0.90)	0.00	0.963

**p<0.005

Figure 4.2

Comparison of AVQI and It's Constituents Between Male Carnatic Singers and Non Singers

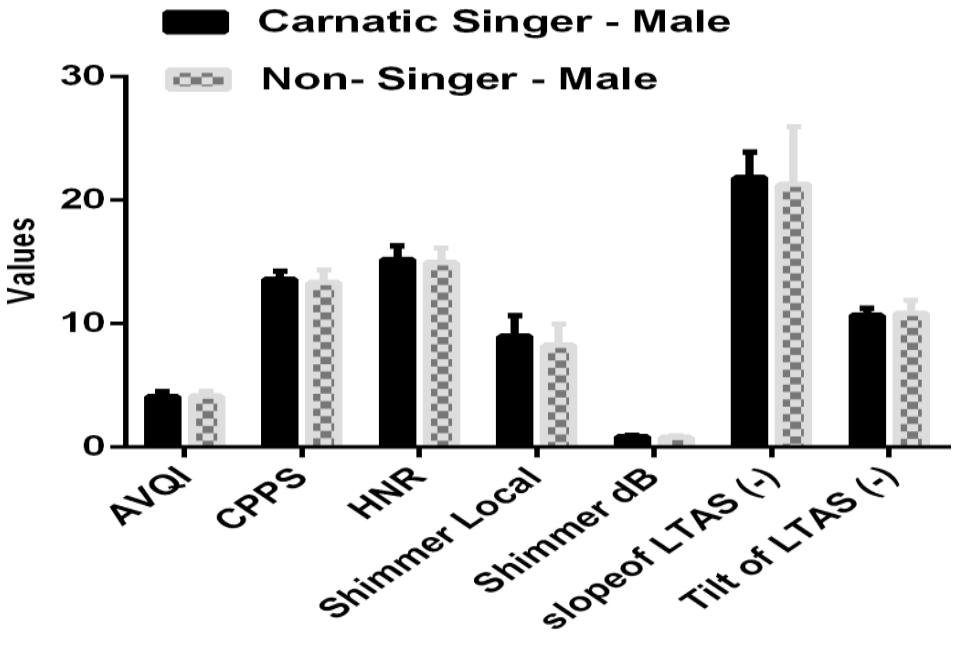
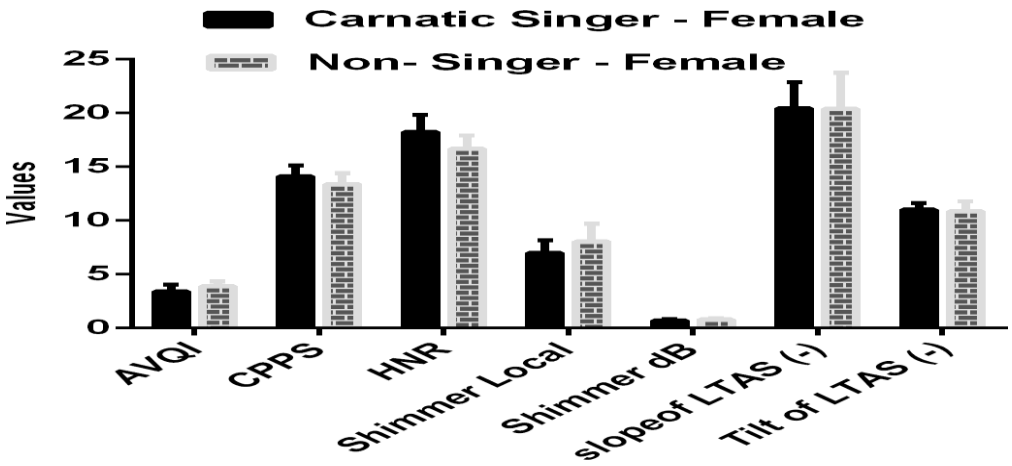


Figure 4.3

Comparison of AVQI and It's Constituents Between Female Carnatic Singers and Non Singers



Effect of experience on AVQI scores and its constituents:

The Carnatic singers were grouped in to two based on their experience the first group had,. One-way ANOVA was carried out to find the effect of experience on AVQI between two groups of Carnatic singers. The values are depicted in table 4.3.The mean value for AVQI is 3.28(±0.77) for Carnatic singers who have an experience of 15 years and above and 3.88(±0.42) for Carnatic singers who have less experience. Hence, the results suggest that there is a better voice quality in singers who are more experienced and it was also found that there was a significant difference for AVQI score ($p=0.01$) and in one of the constituent parameter shimmer dB ($p=0.03$) between the groups suggesting experience have an effect in AVQI. Figure 4.4 depicts the comparison of AVQI and its constituents between Carnatic singers based on experience.

Table 4.5

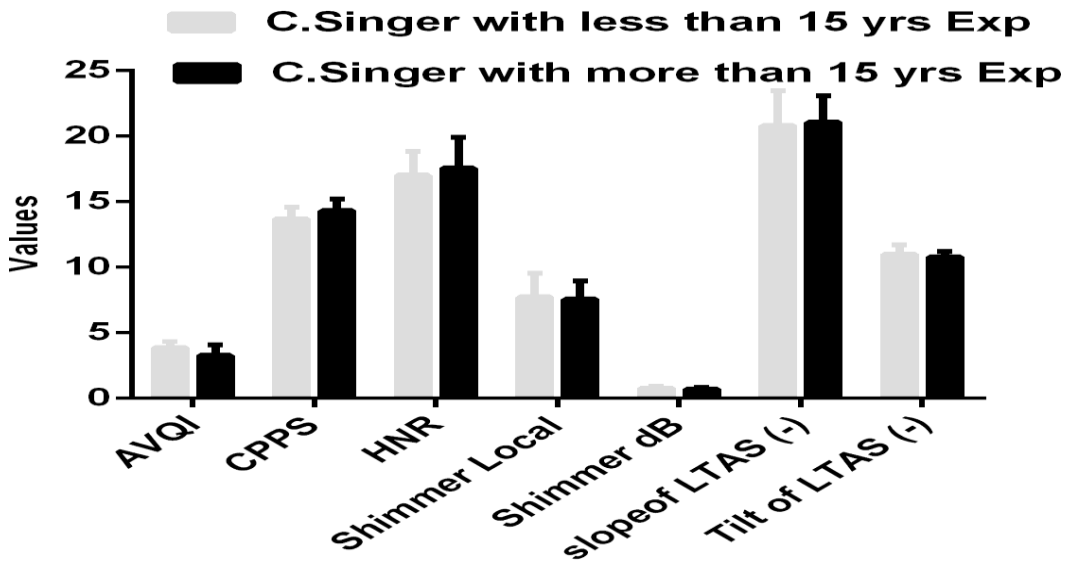
Mean, Standard Deviation F Value And P-Value Between Carnatic Singers Based On Experience

Parameter	**Experience less than 15 years Mean and SD (n=18)**	**Experience 15 years and above Mean and SD (n=12)**	***F* value**	***p*-value**
AVQI	3.88(±0.42)	3.28(±0.77)	7.45	0.01*
CPPS	13.72(±0.86)	14.32(±0.88)	3.39	0.07
HNR	17.02(±1.81)	17.58(±2.35)	0.52	0.47
Shimmer local	7.74(±1.79)	7.57(±1.37)	0.71	0.79
Shimmer dB	0.80(±0.10)	0.71(±0.10)	4.68	0.03*
Slope of LTAS	-20.82(±2.62)	-21.07(±2.02)	0.07	0.78
Tilt LTAS	-11.00(±0.68)	-10.80(±0.40)	0.87	0.35

*p<0.05

Figure 4.4

Comparison Of AVQI And It's Constituent's Between Carnatic Singers Based On Experience



Chapter -v

Discussion

Several researches have accounted a good reliability and validity for various multi parametric measures such as Acoustic voice quality index, Cepstral spectral index of dysphonia and Dysphonia severity index for assessing voice quality and quantifying dysphonia severity compared to other single parametric measures. The AVQI is recognized to be more ecologically valid as it uses both continuous speech and sustained vowel for voice analysis. Henceforth, the present study was focused to establish the AVQI data in Carnatic classical singers and compare AVQI value with age and gender matched Non singers.

Comparison of AVQI and its constituent's across Carnatic singers and Non singers:

The results suggest that there is a significant difference across group in mean AVQI value ($p=0.05$), Carnatic singers obtained a lower AVQI score compared to Non singers, 3.64(±0.65) and 3.99(±0.41) respectively. From literature, it is known that AVQI Quantifies voice quality using a scale ranging from 0-10 in which 0 points to normal voice and 10 points to severe dysphonia, hence, the current results suggests Carnatic singers have a relatively better voice quality compared to non singer group. Similar findings are also there in the study done by Awan and Ensslen (2010), Maruthy and Ravibabu (2015) in Carnatic classical singers were there was a significant difference existed among trained younger Carnatic singers and non singers in terms of mean DSI values and some of its constituents such as Highest fundamental frequency ((F0-high)) and Maximum phonation time (MPT). Prasad and Geetha (2015) compared the DSI

scores of Pre pubertal female Carnatic singers and non singers and found a greater DSI value for Carnatic singers. Gunjawate et al. (2018) reviewed 26 studies on acoustic measures of the voice of singers. Several acoustic measures such as F0, perturbation, cepstral, spectral,DSI, SPR etc. were measured and revealed that singers have a better voice quality than non singers (Arunachalam et al., 2014; Awan & Ensslen, 2010; Balasubramanium et al., 2015; Brown et al., 1993; Brown et al., 2000; Cesari et al., 2012; de Almeida Bezerra et al., 2009; Delviniotis, 2013; Dong et al., 2014; Echternach & Richter, 2012; Gunjawate et al., 2015; Guzman et al., 2013; Hakes et al., 1988; Hamdam et al., 2008; Hanayama et al., 2009; Hoffman-Ruddy et al., 2001; Larrouy-Maestri et al., 2014; Lundy et al., 2000; Maruthy & Ravibabu, 2015; Mendes et al., 2013; Omori et al., 1996 ;Peppard et al., 1988; Prakup, 2012; Rehder & Behlau, 2008; Rothman et al., 2001; Sataloff et al., 2012)

There is a continuous training and practice from childhood itself for most of the Carnatic singers were they focus to sing in right shruthi or pitch with proper maintenance of proper breath support along with open throated singing on a forward placement of voice (Boominathan, 2014) for achieving a good proficiency in singing. Carnatic classical singers might also be using their voice in a very careful and precise manner hence, singers will be having a delicate and meticulous control over respiratory, phonatory and velopharyngeal muscles according to Sundberg (1990).This might be a reason in Carnatic singers for attaining comparatively better AVQI values over non singers. The AVQI values obtained for both the groups in the present study are in concordance with study done by Jayakumar and Jesnu, (2017) in malayalam and kannada speaking phononormals however the AVQI values were slightly higher.

For CPPS even though there is no statistical significance(p=0.06) but on careful inspection it can be observed that the values for CPPS in Carnatic singers was slightly higher 13.96(±0.91) compared to nonsingers13.39(±0.99).This results almost corresponds to the study done by Balasubramanium et al., in 2015 were they found that Carnatic classical singers obtained a higher mean value over non singers and their findings suggest that, as cepstral measures gives information regarding signal having the extent of harmonic organization for Carnatic singers. Durga (1978) also suggested that Indian Carnatic singers have better harmonic organization which is adding richness to their singing voice. Current study also shows a significant difference in HNR (P=0.01), Carnatic singers obtained a higher Mean HNR value compared to non singers. This results are in accordance with the observation of Yoo et.al., 2002 were they found a significant difference on HNR for classical singing students over other college students .As literature suggest this might be due to increased harmonic organization and greater vocal dynamics in singers compared to non singers.

Effect of Gender on AVQI and its constituents

Analyzing the effect of gender across the group found that there was an impact of gender on AVQI scores, HNR and shimmer local. Mean AVQI value and Shimmer local value was lower for females than males. The HNR value obtained for males was lower compared to females. Considering the results of gender comparison on Carnatic classical singers it was found that there was an effect of gender for Carnatic singers on AVQI and its constituents such as HNR, shimmer local and Shimmer dB. Even though earlier discussed results showed a gender effect on AVQI and its constituents while analyzing gender comparison on non singer group revealed no statistical significance except for

HNR, here it was found that the male non singers obtained a lower value for HNR compared to female non singer group. Several studies have carried out in different languages and populations on AVQI to find the gender effect and most of the studies have reported of no effect of gender on AVQI. The results from non singer group are in coherence with the literature. From the study done by Jayakumar et al., (2020) with AVQI version 2.02, it was revealed no significant gender impact on HNR, CPPS and Shimmer dB. Goy et al (2013) found a comparatively higher value on HNR for females, this might be because of the structural and physical changes across gender. In the current study HNR measures in all the three comparisons also revealed, females have a higher HNR compare to males. Heffernan (2004) on comparing the voice of males and females of Canadian English and Japanese also found lower HNR in males compared to females in both the group. Brockmann et al (2008) also suggested significant difference across gender on perturbation measures he found a lesser Shimmer in male compared to female on soft and medium phonation task. . The probable gender effect on these measures supposed to be the result of structural and physiological differences. Teixeira and Fernandes (2014) analyzed jitter, Shimmer and HNR parameters of voice in 7 males and 34 females. HNR and Shimmer local, shimmer dB were seen to be comparatively lower in males than females, but a significant difference was not observed.

In the present study even though there is no significant difference on CPPS across gender but on closer observation the values obtained by males was slightly lower compared to females. However previous studies done by Awan (2010), Garett(2013), Pooja and Rajasudhakar(2015) Jayakumar et al., (2020) have mentioned that males have a higher CPPS value compared to females as females having posterior glottic gap during

vocal fold vibration (Linville(1992), Chandran et al (2011), Sodersten 1997) which could have been contributed for increased noise measures. The present study findings in CPPS are not in accordance to earlier quoted studies. This may be due to small sample size of male participants. Further studies have to be carried out with equal number of male and female participants for more clarity.

Effect of experience on AVQI scores and its constituents:

The results reveal that more experienced Carnatic classical singers obtained a significantly lower AVQI score 3.28(±0.77) than less experienced Carnatic singers 3.88(±0.42) (p=0.01). This finding from the present study reveals that more experienced singers have slightly better voice compared to non singers. The findings are in accordance with literature. Moorhead et al., (2011) reviewed ten studies (Chan,1994; stemle et al., 1994; Broaddus-Lawrence,2000; Lehto et al.,2003; Duffey & Hazlett,2004; Timmermans et al., 2004; Lehto et al., 2005; Bovo et al.,2007; Pasa et al., 2007; Illomaki et al., 2008) to find whether voice training have an impact on quality of voice among professional voice users. All the studies showed a significant difference in at least one of the voice parameters indicating better voice quality in individuals undergoing voice training, and the rationale was better respiratory and phonatory coordination, better knowledge and practice of vocal hygiene and vocal warm-ups. Awan and Ensslen(2010) compared the voice of trained and untrained vocalist using DSI and found that the trained singers has higher DSI value (6.48) than untrained singers (4.00) meaning trained vocalist have a better voice. A Study done by Pooja and Rajasudhakar in 2015 aimed at investigating CPP and CPPS along with fundamental frequency in three different grades (junior, senior and vidwath) of Carnatic classical singers. Their study suggest there was

no significant difference across grades however among female Carnatic Singers the ,vidwath grade singers have higher cepstral measures which reflect a good harmonic organization of voice in comparison with the junior and senior grade singers. According to the study done by Joshi & Raju, (2016) comparing the amplitude of singer's formant and singing power ratio across 3 groups i.e., non-singers, singers with less than 5 years of training and singers with 5-10 years of experience it is found that amplitude of singer's formant and singing power ration increased as years of experience increased. Mendes et al.,(2003) reported a decrease in jitter and Shimmer and increase in speaking fundamental frequency within each semester in voice students indicating better voice quality with training.

A high quality of voice is necessary for every singer in order to produce good music. The vocal mechanism is brought in to complete obedience through proper years of training. This process of bringing the voice under control is known as voice culture in the field of music (Durga, 1978) Hence, the findings from the current study also suggest that experience have an effect on quality of voice.

Chapter - VI

Summary and conclusion

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Acoustic voice quality index is a multi parametric acoustic analysis developed by Maryn et al.,(2010).Researches have proved that AVQI is one of the promising measurements among multi parametric measures, which is easy for evaluation and interpretation. AVQI is obtained through a combination of six constituent parameters, such as CPPs, HNR, Shimmer local, Shimmer dB, slope and Tilt of LTAS. Literature suggests that along with phonation the addition of continuous speech makes AVQI more advantageous over other multi parametric measures.

Several studies have been validated AVQI and standard norms are developed in various languages, age groups, and also in professional voice users like theatre artist. Therefore the current study was taken up with the aim to estimate and validate AVQI data for Carnatic singers and compare it with non singers. The present study focused in Carnatic classical singers with age range of 18-35 years. 60 participants were enrolled for the study, in which 30 participants were Carnatic classical singers. AVQI and its constituent's were measured from sustained phonation and reading sample using AVQI script 2.02 given by Maryn et al.,(2010).

The obtained values were entered in SPSS version 20 software for statistical analysis. The mean and SD for AVQI and its constituent's of Carnatic singers and Non singers were found using descriptive statistics and MANOVA was used for the comparison across groups. Results shows, mean value of AVQI in Carnatic singers were significantly lower compared to non singers, suggesting a better voice quality in Carnatic

classical singers than non singers. However, other constituent like Shimmer local, Shimmer dB, Slope and Tilt of LTAS did not shows any significance. With respect to gender MANOVA was administered, results reveals within group of Carnatic singers, gender shows an effect in AVQI and few of other parameters such as HNR, Shimmer local and Shimmer dB. However, on observation of MANOVA results, within non singer group such gender effect was not seen except for HNR.

Considering the effect of experience, one way ANOVA was carried out and it was revealed that Carnatic classical singers with more experience obtained a lower AVQI values than Carnatic singers with less experience which explains that training and experience in singing attributes to a better voice quality. The present results confirm that there is an effect of Carnatic classical singing on AVQI and singers have a better voice quality compared to non singers.

Clinical implication of the study

- The reference value of AVQI obtained for Carnatic singers will give more knowledge about unique voice characteristics pertaining to trained Carnatic classical singers, which can be compared with other related studies on the voice characteristics of Carnatic singers.
- It helps in voice assessment and management in Carnatic classical singers.

Limitation of the study:

- The distribution of the number of singers according to gender and experience was unequal.
- More extensive demographic details such as hours of practice should have been included.
- More number of participants could have been enrolled for the study for better results and findings.

Future directions:

- Effect of gender on AVQI and its constituents for Carnatic classical singers can be studied further with equal distribution of the number of male and female singers.
- AVQI normative can be estimated for other groups of singers and other professional voice users.

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Appendix

Malayalam reading passage

100 Words Passage- Malayalam

ഒരിടത്ത് ഒരു ബ്രാഹ്മണൻ ഉണ്ടായിരുന്നു. അന്ധവിശ്വാസങ്ങൾക്ക് അടിമയായ അയാൾക്ക് ജീവിതത്തിൽ ഒരുപാടു പ്രശ്നങ്ങൾ നേരിടേണ്ടി വന്നു. തടിയനായിരുന്നതിനാൽ ജനങ്ങൾ അവനെ "പൊണ്ണത്തടിയാ" എന്നു വിളിച്ചു. ആര്, എന്ത് വിശേഷാവസരത്തിനു ക്ഷണിച്ചാലും മുൻപേ ഇവൻ ഹാജരാകുമായിരുന്നു.

ഒരു ദിവസം 'ധനപതി'യെന്ന ബാല്യകാലസുഹൃത്ത് ബ്രാഹ്മണനെ തന്റെ മകളുടെ ജന്മദിനാഘോഷത്തിനായി ക്ഷണിച്ചു. എന്നാൽ, സ്നേഹിതന്റെ വീട് ബ്രാഹ്മണന്റെ വീട്ടിൽ നിന്നും ആറു കിലോമീറ്റർ അകലെ ആയിരുന്നു. നടന്നു പോയാൽ ആരോഗ്യത്തിനു നല്ലത്. കൂടാതെ, കൂടുതൽ വിശന്നാൽ ഭക്ഷണം കൂടുതലും കഴിക്കാം. ബ്രാഹ്മണൻ തീരുമാനിച്ചു.

ജന്മദിനാഘോഷത്തിന്റെ ദിവസം എത്തി. ഒരുക്കങ്ങളെല്ലാം വേഗത്തിൽ നടത്തി വീടിനു പുറത്തേയ്ക്കിറങ്ങിയപ്പോൾ ഒരു കുഷ്ഠരോഗി മുൻപിൽ പ്രത്യക്ഷപ്പെട്ടു. ശകുനം ശരിയല്ലെന്നു പറഞ്ഞ് വീട്ടിനുള്ളിലേയ്ക്കുതന്നെ കയറിപ്പോയി. ഇതുപോലെ മൂന്നു പ്രാവശ്യംകൂടി സംഭവിച്ചു. പിന്നീട് അയാൾ വേഗത്തിൽ നടന്ന് സ്നേഹിതന്റെ വീട്ടിലെത്തി. അപ്പോൾ അവിടെ എല്ലാവരും ഭക്ഷണം കഴിച്ച്, താംബൂലം ചവച്ച് വിശ്രമിക്കുകയായിരുന്നു.

വൈകിവന്ന ബ്രാഹ്മണനെ കണ്ട് ധനപതി "എന്തേ ഇത്ര വൈകിയത്? ഭക്ഷണത്തിനുള്ള സമയം കഴിഞ്ഞുപോയല്ലോ", എന്നു പറഞ്ഞുകൊണ്ട് തണ്ടുവാഴപ്പഴവും പാലും വരുത്തി കൊടുത്തു.